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FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser
(Report on Norwegian Fishery and Marine Investigations Vol. IV, No. 8)

Published by the Director of Fisheries

Some Observations on Cod in Northern Waters

Preliminary Report

By
THOR IVERSEN

Investigations carried out by Grants from the Government and Fiskeribedriftens Forskningsfond

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A.s John Griegs Boktrykkeri, Bergen

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After the termination of the World War the Norwegian fishery investigations in northern waters have been continued during the last ten years from 1923 with the exception of the year 1927. These investigations have mainly had as aim practical purposes, i. e. fishing experiments. Exclusively leased vessels have been employed. In the early four years motorpowered vessels of about 50 gross tons were used, but later on somewhat larger motorvessels and steamships of 150—200 gross tons were engaged. In the largest extent possible, with small vessels fitted solely for the purpose of fishing and sealing in Arctic, a lot of material of scientific value has been collected, comprising examinations of the water layers and investigations of biological interest. The localities where these investigations have been conducted cover the Barentz Sea, the Bear Island and Spitzbergen Area and the waters off Southeast Greenland and Jan Mayen. In cooperation with the fishery investigations hydrogaphical material has been gathered through a period of years by various Norwegian expeditions to Bear Island and Spitzbergen.

As an orientation a brief account is given here summarizing the knowledge we have gained of the occurence of fish on the various fishing grounds in past years.

In the following I use the terms: the "Bear Island Area", the "Hope Island Area" and the "Spitzbergen Area".

By the term: the "Bear Island Area" I mean in this connection the bank surrounding Bear Island, including also the major part of the bank between Bear Island and Hope Island. This bank is on the drafts designated as the "Spitzbergen Bank", a name not in common use.

By the term: the "Hope Island Area" I mean the bank within a sector extending ab. 75 nautical miles from Hope Island.

By the term: the "Spitzbergen Area" I mean the bank and coastal waters along the west and north coast of Spitzbergen.

In the southern portion of the Barentz Sea where formerly the fishing was practised exclusively as a coastal fishery the deep sea banks were not utilized till the beginning of our century. (Fishery of the Greenland shark is not taken into consideration.

Concerning the occurence of fish in the Bear Island Area we know that cod was caught near the coast of Bear Island by Norwegian hunters who wintered there in 1825 and 1865. Furthermore, large numbers of cod were met with in this area and in the fjords and coastal waters on the west and northwest side of Spitzbergen in a period of years from 1873—1882. The stock of fish at Spitzbergen was exploited by a fleet of Norwegian vessels. The fishing was practised with hand-lines from row-boats in rather shallow water. In 1874 the catch amounted to 37 000 cod, in 1882 the catch was 249 400 cod. The yield of the fishery varied considerably in the intervening years with the largest catch in 1879. That year the fishery yielded 595 000 cod. Also in 1883 18 Norwegian vessels went to Spitzbergen, but by then the cod had entirely disappeared. The total catch of the latter year has been stated as 3 cods.[1])

In 1898 the German "Olga Expedition" carried out fishing experiments with trawl and long-lines in the fjords and on the banks off West Spitzbergen and in Bear Island waters. This expedition did catch fish, mainly cod and haddock, on the banks in said waters; the catches, however, were small. Fishing trials in the Spitzbergen fjords did not yield any catch. At the instance of the investigations of the "Olga Expedition" Germany sent out another expedition for economical purposes to Bear Island in 1899; this expedition was planned on a larger scale. Fishing operations were carried out with trawl and longlines. The catches were, however, exceedingly poor, and the expedition proved a complete failure.

After the commencement of the nineteenth century fishery investigations have been carried out in the Barentz Sea for a number of years mainly by Norway and Russia, but also by other nations and by Germany in particular. The Norwegian and Russian investigations issued in a general exploitation of the deep sea banks in the south-eastern portion of the Barentz Sea. Norwegian fishing experiments with the leased fishing steamer "Skolpen" in 1902 encountered a rich stock of cod on the extensive deep sea bank situated to the north of the Murmansk Coast. This bank is commonly referred to as the "Skolpen Bank" a name which is now generally known. Also in 1905—1906—1907 and 1914 extensive Norwegian fishing experiments were carried out in these waters south of 72° Latitude and eastwards to Cape Kanin. The deep sea banks in this area have been visited by trawlers from the North Sea countries every year from 1905 and including that year.

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[1]) The cod was mainly feeding on the odious pteropod *Limacina helicina* causing an obnoxious odor and taste to the flesh of the fish.

In 1914 additional fishing experiments with trawl and long-lines were carried out in several localities along 35° E. Long. between 72° and 75° Lat. Also in this locality cod and haddock were encountered; they were, however, essentially caught on floated lines in the intermediate water layers. (Cod and haddock are indeed frequently found pelagically in all waters covered by our investigations).

In the Bear Island area Norwegian fishery investigations have been carried out for a number of years preceeding the World War. Cursory fishing was carried out in 1901 by dr. Johan Hjort with the "Michael Sars". The experiments were few, but one set of long-lines on the bank to the west of Bear Island yielded a noteworthy large catch of halibut.

In 1905—1906 and 1914 more extensive fishing experiments were carried out in this area during the summer season. The stock of halibut proved to be fairly large, and would with the prices obtained for halibut nowadys have been workable; at that time, however, the prices for halibut were too low. Cod and haddock were found in said year, but they were as a whole so scarce that the stock of fish could not be deemed workable.

The Bear Island area has after the war been investigated in 1924 and subsequent years with the exception of 1927. In 1924 the fishing experiments yielded on an average small unprofitable catches. In 1925, however, good catches of cod were made during the month of June. The knowledge of this result summonded already in the same year one Norwegian and several foreign fishing steamers. The stock of fish has subsequently been so uniformly good in this area that it has since been commercially exploited every year.

Our investigations during the summer of 1926 proved the presence of a fairly large stock of cod. In 1928 the investigations were extended till the end of October with good results from the fishing experiments also at that late season. In 1929 both the investigations and at the same time also the commercial fishing operations were impeded by drift ice which covered the major portion of the Bear Island waters from the latter part of May till July. In 1930 fishing experiments were carried out as early as at the end of April. The catches of cod were good at that season and later on during the summer. In 1931 fishing experiments in early part of April and later on in spring yielded catches of cod, although these were not so uniformly good as in spring of the previous year.

In the Hope Island area experiments with long-lines on the edge of the bank to the east and southeast of Hope Island at the end of August 1923 proved the presence of a rich stock of cod. Fishing

experiments in this locality during July and August 1924 yielded, however, very poor catches. In 1930 a large stock of cod was found on the edge of the bank to the southeast of Hope Island in July, while fishing trials in the identical localities in September yielded poor catches. Also these fishing grounds have in any case been commercially exploited in some of the subsequent years.

In the Spitzbergen area the "Olga Expedition" has, as previously mentioned, carried out fishery investigations in 1898. One solitary fishing trial with long-lines on the bank off Bell Sound was carried out by the "Michael Sars" in 1901; but this experiment did not result in any catch of cod and haddock. This area was not investigated during the subsequent years till 1923.

In 1923 this area was thoroughly investigated in summer. Cod was encountered on the edge of the bank between Horn Sound and Kings Bay, but they occurred only in sparse numbers. Haddock, and likewise catfish, appeared to be somewhat more numerous along the entire bank from the southern to the northern point of Spitzbergen. Experiments with long-lines and hand-lines off the north coast did not yield catches of cod nor haddock, neither did fishing trials with long-lines at the mouth of Ice Fjord and in Green Harbour. Some young cod were caught with beach seine in Green Harbour.

Some cursory fishing experiments in 1924 on the edge of the bank and extending from the southern point of Spitzbergen to west of Ice Fjord yielded poor catches of cod and haddock.

The bank off Ice Fjord and Bell Sound was investigated rather thoroughly in the course of July 1925; the conditions then proved to be very dissimilar from those in previous years. Both cod and haddock were found not only on the edge of the bank, but also on the more shallow portions of the bank. Also in the Ice Fjord with Green Harbour, Coles Bay and Advent Bay cod and haddock were caught on long-lines this year. On the bank the yield of cod was on an average larger than the yield of haddock; in some cases it was even considerable. In said fjords the catch of cod was poor, while several sets of long-lines yielded large catches of haddock.

At the end of July and in August 1926 fishing trials with long-lines on the bank to the west of Ice Fjord yielded exceedingly poor catches of cod, but fairly large and partly rich catches of haddock. Fishing experiments in Green Harbour and in Advent Bay this year did not yield any catches worth mentioning.

In early days of September 1928 cursory fishing experiments on the bank proper and in Green Harbour and Advent Bay did not yield any catch.

Fishing experiments at the beginning of July 1930 with long-lines on the bank to the west of Ice Fjord did not result in catches worth mentioning; on the other hand, fishing experiments in the same locality in the first days of September yielded large and remunerative catches of cod, whereas the catches of haddock were insignificant. In the fjords the presence of fish was not detected.

About the middle of June 1931 preliminary fishing trials with long-lines were carried out on the edge of the bank off Ice Fjord, these experiments resulting in large catches of cod; the yield of haddock were, however small. Subsequent fishing experiments during the latter part of August and early half of September in the identical locality did not result in catches of cod and haddock worth mentioning, while on the other hand the shallow portion of the bank yielded fairly large catches of haddock. On the north coast of Spitzbergen off Red Bay a fairly large stock of cod of the younger age groups was encountered in shallow water in the first days of September. One set of lines on 80° 9′ N and 12° E gave as result only one cod.

On Dec. 15th 1932 a set of lines on the edge of the bank to the west of Ice Fjord yielded a fairly large catch of cod, but only an insignificant number of haddock.

From the preceeding it will be seen that the stock of cod in this area is subject to great variations from one year to another as well as within the same season. Commercial fishing operations has not as yet been carried on in this area.

In the Spitzbergen area the following fishes have been found during our investigations (Common C. Rare R.):

Cod *(G. callarias)* C	*Gadus saida*
Coalfish *(G. virens)* R	*Onos reinhardti*
Haddock *(G. aeglefinus)* C	*Cottus scorpius*
Tusk *(Br. brosme)* R	*Gymnocanthus tricuspis*
Halibut *(H. vulgaris)* C	*Artediellus uncinatus*
Greenland Halibut *(R. hippoglossoides)* R	*Icelus hamatus*
Long rough Dab *(Hip. platessoides)* C	*Triglops pingelii*
Catfish *(An. lupus)* C	*Agonus decagonus*
„ *(An. minor)* C	*Lumpenus medius*
„ *(An. latifrons)* R	„ *maculatus*
Norway Haddock *(S. marinus)* R	„ *lampetriformis*
Herring *(Cl. harengus)* R	*Liparis liparis*
Spitzbergen Char *(S. stagnal's)* C	*Careproctus reinhardti*
Dogfish *(Squalus acanthias)* R	*Eumicrotremus spinosus*
Greenland Shark *(Somn. microc.)* C	*Lycodes pallidus*
Starry Ray *(R. radiata)* C	„ *rossi*
Lump-sucker *(Cycl. lumpus)*	„ *esmarkii*
Capelin *(Mal. villosus)* R	*Gymnelis viridis*
	Macrurus fabricii

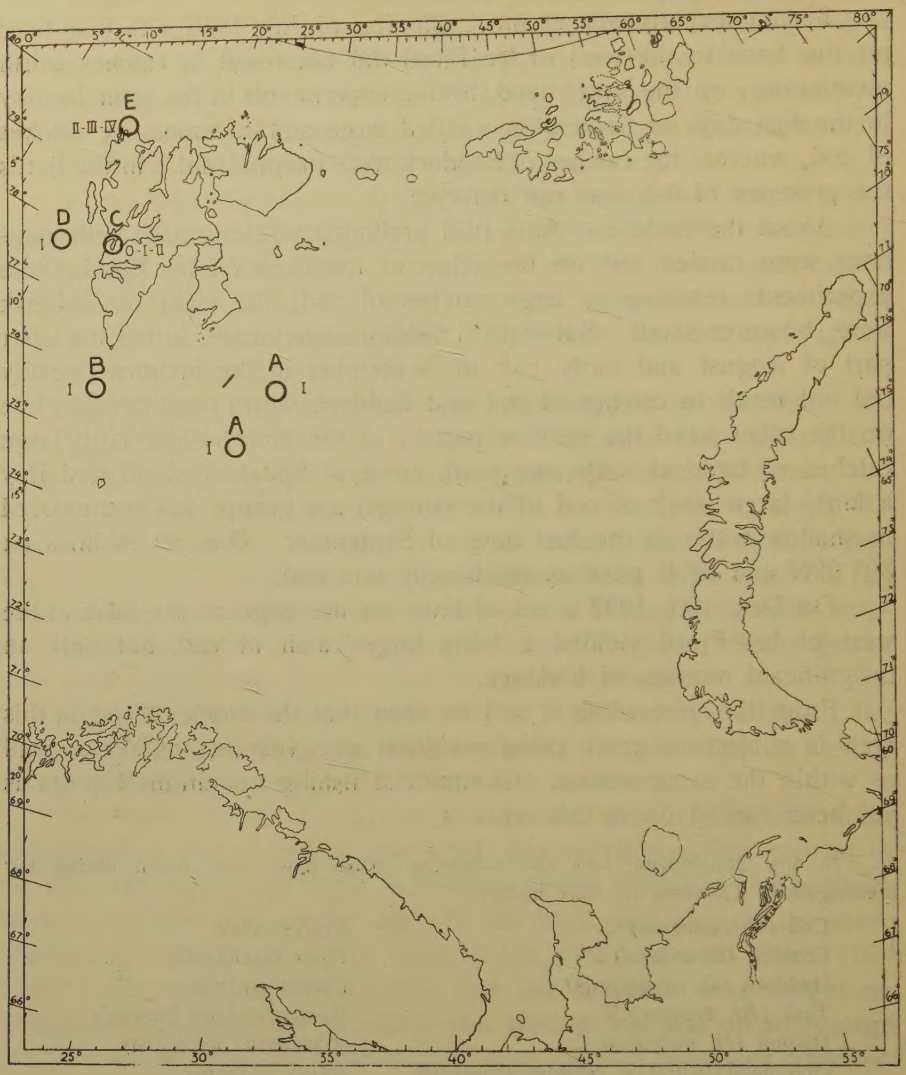

Fig. 1. The Most Northerly Observations of Cod in Size Groups 0—I—II—III—IV. The Circles denote the Area. The Roman Numerals designate Size Groups.

Young cod down to the smallest groups of bottom stages may, practically speaking, be caught in any locality in the southern portion of the Barents Sea and off Bear Island where the water is temperate and where commercial fishing operations are pursued. Table I and fig. 1 show the young cod captured farthest to the north. Most noteworthy is perhaps the catch of the 0-group, only 3·5—6 cm, off the shore of Green Harbour on September 4th 1923. The occurance of

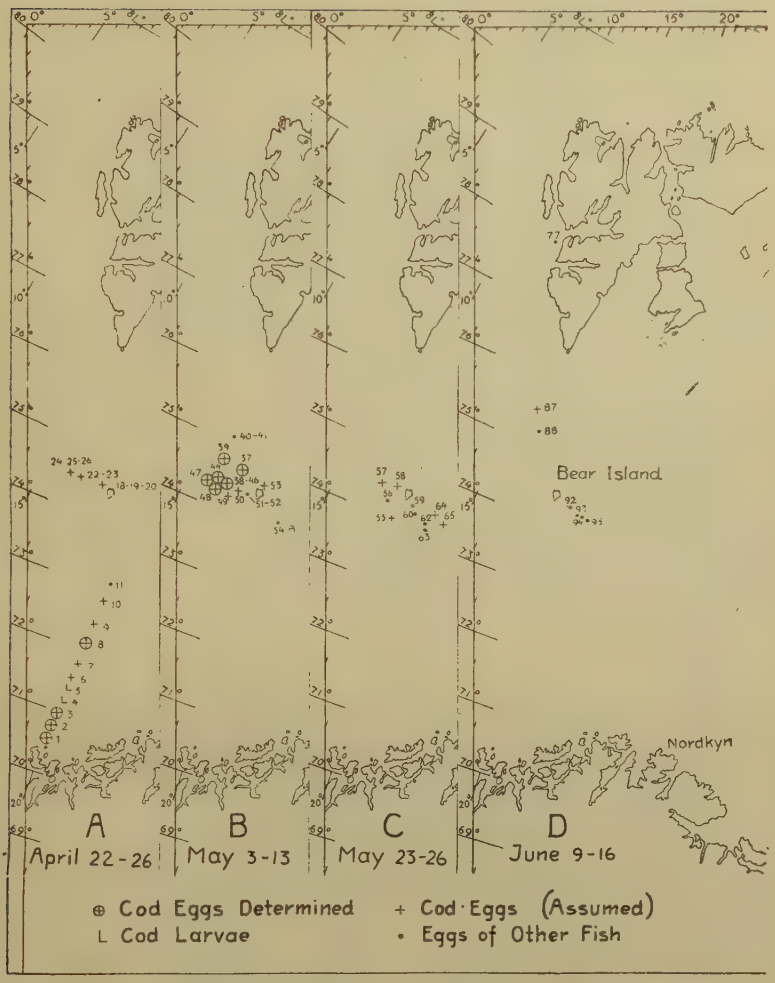

Fig. 2. The Catch of Fish Eggs, 1930.
Surface Hauls with Net 1 m Diam. Figures: Number of the Station.

such small-sized cod in this locality already at that time directed the attention to the problem of spawning in areas of closer proximity to the locality of capture than the well known spawning-grounds off the coast of Norway, and also of spawning at a somewhat later period of the year than what is the case off Norway. Later investigations prove this to be the case in regard to the Bear Island Bank, and some spawning also seems to occur on the edge of the bank off Ice Fjord, Spitzbergen, and it is not improbable that some spawning might take place in the central portion of the south-eastern Barentz Sea where the temperatures of the water are comparatively high. However, if spawning

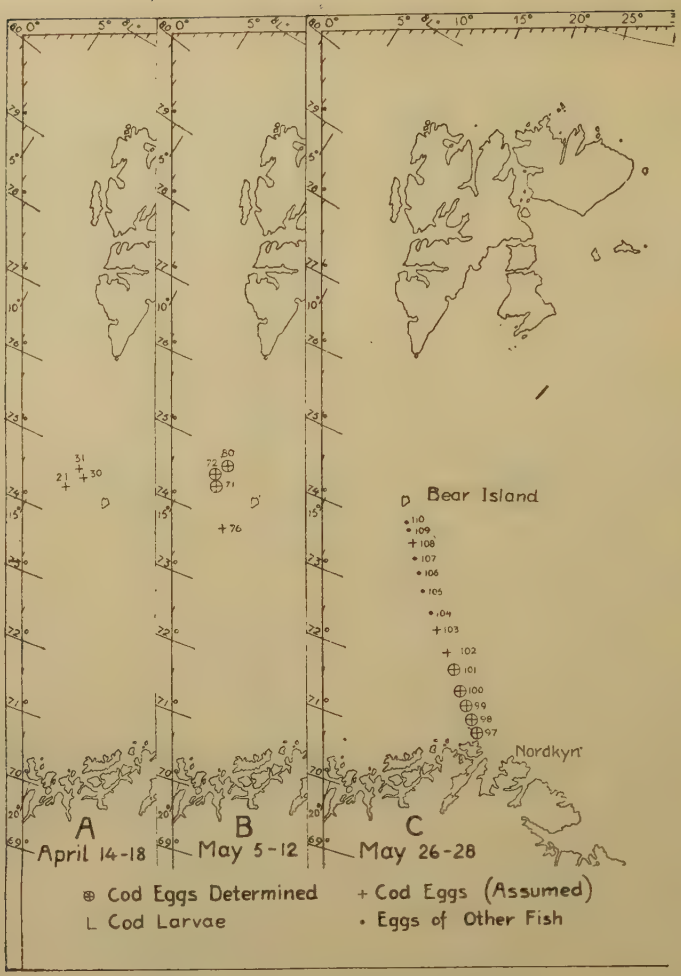

Fig. 3. The Catch of Fish Eggs, 1931.
Surface Hauls with Net 1 m Diam. Figures: Number of the Station.

takes place in these areas every year is not as yet ascertained, and that this is the case is perhaps to be doubted on account of the great variations which might take place from year to year and in periods of years in regard to the drifting ice and the temperature of the water.

From table III concerning the year 1930 it appears that cod in the spawning stage (stage VI) was encountered in the period April 26th—May 10th in the Bear Island area, and on May 29th off Ice Fjord, Spitzbergen. From fig. 2 concerning the same year it will be seen that eggs determined as cod eggs have been caught in surface hauls in early half of June within Bear Island waters. From table IV

concerning 1931 it appears that spawning cod has been captured in the period April 11th—June 2nd in the Bear Island area. Fig. 3 shows that eggs determined as cod eggs have been found pelagically in early half of May in the same area in 1931.

The spawning in these northern waters seems, however, to be so insignificant that it cannot form the foundation for the great masses of cod of every age group which really do occur here, and it does not alter the supposition previously asserted by investigators, namely that the cod stock frequenting the Bear Island and Spitzbergen area and otherwise the Barentz Sea are mainly associated with the spawning grounds off the coast of Norway. Marking experiments carried out by the Russians and Norwegians likewise seem to verify this.

Fig. 4 together with table II, which show the Norwegian marking experiments in 1928, 1930 and 1931, points out among other things that cod released in Bear Island waters has been recaptured at the coast of Norway. And on the other hand that cod marked at the coast of Norway has been recaptured in Bear Island waters. Fig. 5 furthermore give an impression of the migrations of cod in waters dealt with in this report.

*

Investigations of the maturity of the sexual organs of cod have been carried out every year since 1923, but the best material has been collected since 1930, including that year, as at that time we became fully aware of the spawning taking place on the Bear Island Bank and observant of the considerable stock of fullgrown cod with sexual organs which apparently showed that they had not previously spawned or should spawn this same year. This group of cod was subsequently by us termed "Gjelltorsk" (Geld Cod), which correspond to cod with sexual organs in stage II.

During the several cruises Mag. Sci. Einar Koefoed has carried out investigations concerning the maturity of the sexual organs of cod and in his work he has employed the German table of definitions. In this case however, a synopsis has been specially made so as to conform with the cod in particular. Stage I—comprising young cod—has no bearing upon the investigation dealt with in this case and is therefore omitted.

Female ♀

II. The ovarian membrane thin and transparent. The content yellow or red of a more or less firm consistency. (Under the microscope are seen minute and clear eggs not yet obscured by yolk material).

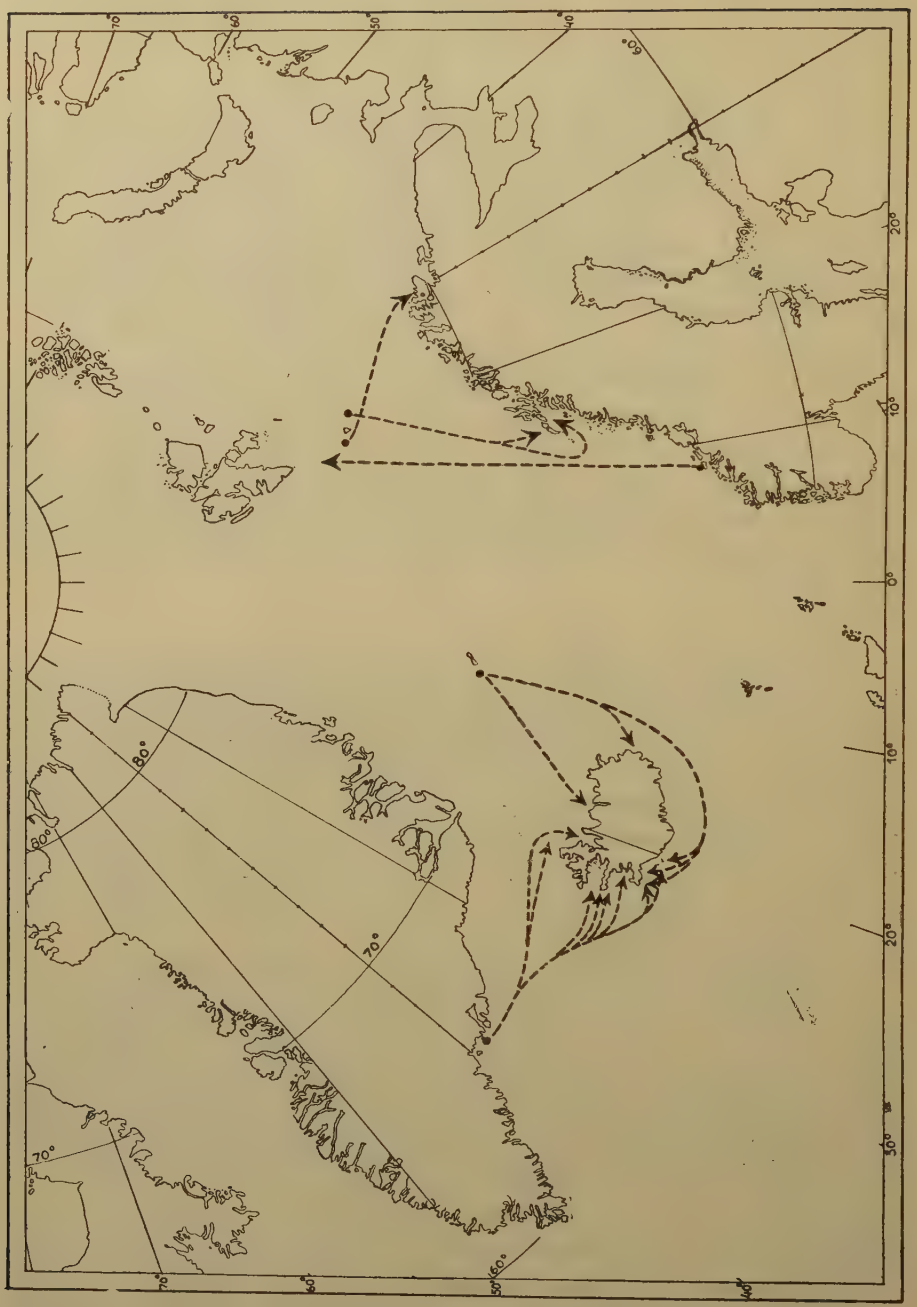

Fig. 4. Norwegian Cod Marking Experiments 1928—30—31.

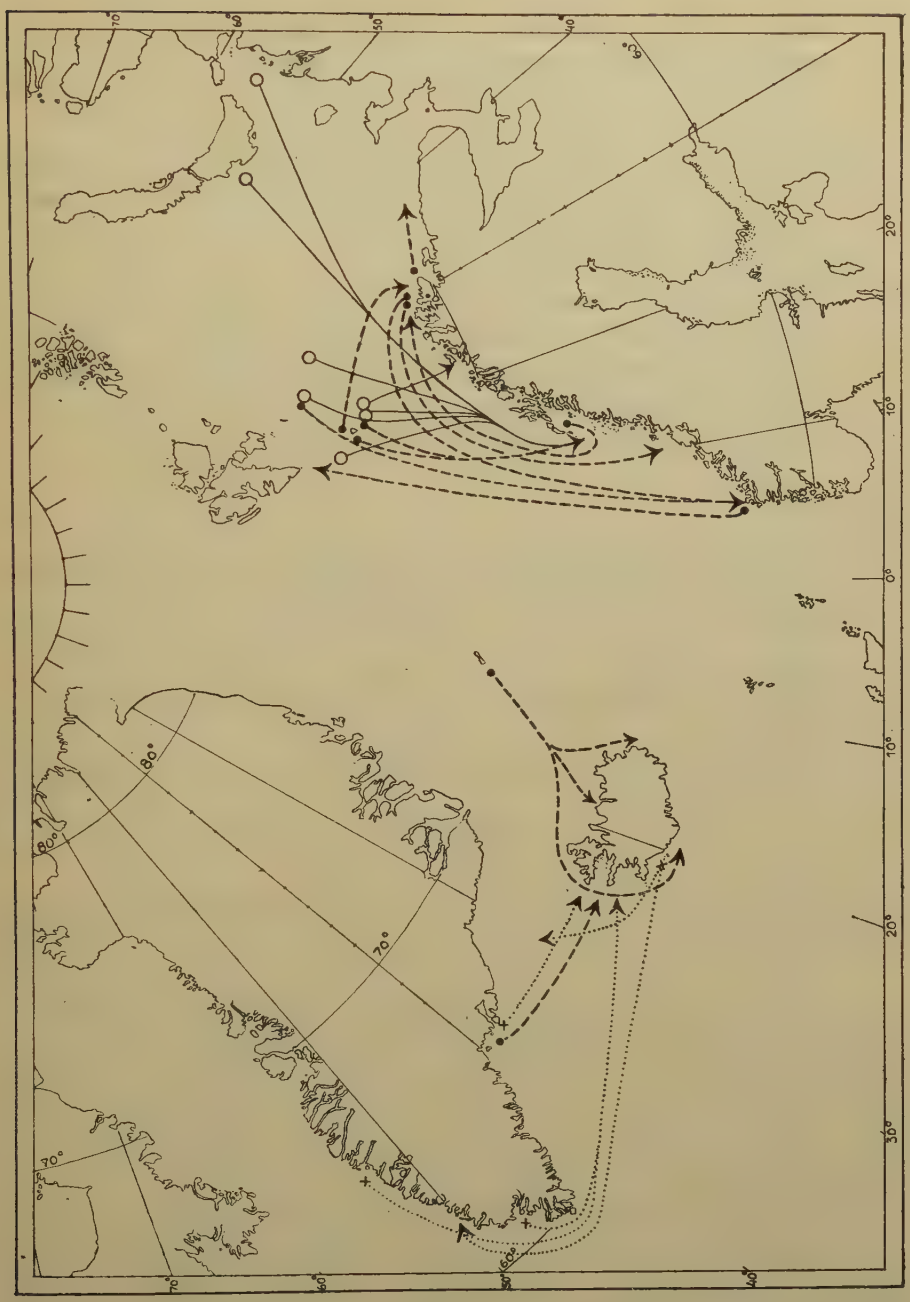

Fig. 5. General View of Cod Migrations, based upon Marking Experiments.
Russian —— Danish ..... Norwegian ----.

III. Membrane thin. The content consists solely of minute yellow, opaque eggs.
IV. Membrane thin. The content consists of minute yellow, opaque eggs interspersed with a few large clear ones.
V. Membrane thin. The content consists of translucent eggs and eggs still yellow and opaque.
VI. Membrane thin. The content almost liquid with translucent eggs.
VII. The ovary of a whitish- or bluish-grey color. The membrane thick and tough, often wrinkled. The content loose and somewhat mucous with some white ova.
VIII. Ovary small and clear, but the membrane has grown cloudy white and somewhat wrinkled and tough. When the ovary is dissected the content appears as a loose, almost mucous mass through which the membrane might be perceived. Occasionally single white and undeveloped ova might be found.

Males ♂

II. The small testes appear as a clear, crimped and slender string.
III. Testes grow gradually white and distended.
IV. Testes white and distended. The fine network of bloodvessels appears regularly.
V. Testes white and distended, but milt does not run when pressure is applied.
VI. Testes white and distended. Milt runs freely by light pressure without any injury.
VII. Testes dwindled, often wrinkled, blood-colored or white. Vas deferens wide and often filled with milt.
VIII. Testes slender, clear or white, the edge regularly filled with blood. Vas deferens a wide, flat ribbon.

In order to controll the applicability of this table of definitions mr. Alf Dannevig, of the State Hatchery at Flødevigen, has upon request kindly carried out some investigations concerning the ovaries and testes of cod. His experiments with cod in aquarium seem to prove that the characteristic qualities tabulated above coincide with his observations.

Dannevig's observations might be summarized as follows:

From December 1931 to Juli 1932 400 cod were examined. The spawners could easily be distinguished from the non-spawners by means of morphological characters only. This proved to be the case also in July, several months after spawning.

The unripe ovaries are recognized by the thin, smooth and transparent membrane through which the light or dark red color is clearly visible. At the same time they are relatively small and firm. The network of blood-vessels in the membrane and within the tissue is relatively little conspicuous.

The characteristic feature of the recently spent ovary is the thick, wrinkled and opaque membrane, cloudy white with a bluish tinge. The membrane grows gradually thin and smooth, but the cloudy white color in any case seems to remain till the month of July. In the beginning the ovaries are, as a whole, long, soft and collapsed. Gradually they grow small and firm, but still in July it is noticeable that they have been more strongly distended. The tissues are softer, somewhat mucous and contain after spawning white remnants of eggs not extruded. In the membrane and tissues there are traces of a more extensive network of blood-vessels. The best criterion whereby a spent ovary is recognized seems to be the thick, cloudy white membrane with the conspicuous bluish tinge never observed in unripe individuals.

During the first succeeding months after spawning the testes show a marked difference in the unripe and spent individuals. The minute and undeveloped testes of unripe cod are of a white or yellowish-white coloring, vas deferens being narrow.

The spent fish have larger testes, and vas deferens bears evidence of having been strongly distended. At the same time the network of blood-vessels is so conspicuous as to give the testes a reddish tinge. The testes contract rapidly, but the conspicuous network of blood-vessels remains and is still easely detected during the month of July.

The percentage distribution of cod with sexual organs in various stages of maturity is shown in figures which are based upon the tables appended. These tables represent the material collected in 1930 and 1931 and in addition the material from the winter 1932—1933.

Although be it admitted that the material is incomplete it gives, however, a picture of interest. The figures showing the percentage distribution of cod in different stages of maturity are based upon the tables appended.

Fig. 6 and table III show the percentage distribution of cod with sexual organs in various stages of development in 1930. It appears that the catches in spring, which particularly are of interest in this connection, preponderately are constituted of cod with sexual organs in stages VII—VIII (spent cod). However, not a small percentage is in stage II (gjelltorsk); this is especially the case during the month of April.

Fig. 6. Maturity of the Sexual Organs of Cod above 70 cm, 1930.
The Sectors show the Percentage Distribution of the Stages of Maturity. II. Unripe (Gjelltorsk). III—V. Maturing. VI. Spawning. VII—VIII. Spent.
Number of Individuals examined and Date of Capture stated.

Fig. 7 and table IV likewise illustrate the conditions in 1931. But what is most noticeable is the fact that in contrast to the preceeding year there is a large percentage of cod in stage II (gjelltorsk) in the catches during the month of April, and the fact that spent cod is almost entirely missing. Spent cod does not predominate in the catches till May and June.

The fishing experiments in these waters in 1930 exhibited a considerably richer yield of cod in spring than did the experiments in

Fig. 7. Maturity of the Sexual Organs of Cod above 70 cm, 1931.
The Sectors show the Percentage Distribution of the Stages of Maturity. II. Unripe (Gjellborsk). III—V. Maturing. VI. Spawning. VII—VIII. Spent.
Number of Individuals examined and Date of Capture stated.

the same period of 1931. And this I attribute to the fact that the influx of spent fish from the spawning grounds off the coast of Norway was so much greater in 1930 than in the succeeding year. Therefore the more stationary "gjelltorsk" had to be predominating in the smaller yield of cod in 1931.

Also on the cruise in winter 1932—1933 the sexual organs of cod were examined during December and February in the largest extent possible. On account of insufficient funds the investigations unfortu-

Fig. 8. Maturity of the Sexual Organs of Cod above 70 cm in Winter 1932—33. The sectors show the Percentage Distribution of the Stages of Maturity. II Unripe (Gjelltorsk), III—V Maturing, VI Spawning, VII—VIII Spent.

nately had to be discontinued before the spawning time of the cod. The material is not extensive enough for drawing decided conclusions, but it gives in any case a fair illustration of the conditions in the various areas of northern waters at that season of the year. These conditions are presented in table V and fig. 8.

In this table the cod in each area are divided into two groups according to size, i. e. individuals 70—95 cm and individuals above

95 cm. The two groups are again added to form one group corresponding to those in preceeding tables.

When in the same way the data from the boundary areas 3 and 4 are divided into two groups with individuals ranging from 70—89 cm and 90—109 cm the ensuing facts appear as regards area 3 and 4:

Area 3 (Bear Island) December 11th—December 22nd.

Of 36 individuals 70—89 cm 11 % were in stage II and 89 % in stage III—V. In the group above 89 cm of 15 individuals 13·5 % were in stage II and 86, 5 % in stage III—V.

Area 3 (Bear Island) February 13th—February 15th.

Of 112 individuals in group 70—89 cm 65 % were in stage II and 35 % in stage III—V. In the group above 89 cm of 64 individuals 37·5 % were in stage II and 62·5 % in stage III—V.

Area 4 (Cape Kanin) January 2nd—January 5th.

Of 70 individuals in the group 70—89 cm 55 % were in stage II and 45 % in stage III—V. In the group above 89 cm of 30 individuals 33·3 % were in stage II and 66·7 % in stage III—V.

*

The Spitzbergen, Hope Island and Bear Island areas can as a whole be classed as what I may term "Boundary Areas" i. e. seas where warm and cold bodies of water wrestle for supremacy and where drifting ice is formed in winter. Large portions of the Barentz Sea also come within this definition.

In these boundary areas the temperature of the water layers varies as to the seasons of the year as well as from one year to another. It must be assumed that such variations exert an influence upon the occurrence of the shoals of cod in the various localities.

The hydrygraphical material from these localities is very extensive but is not as yet at issue scientifically treated, and therefore a survey of the hydrographical conditions in the waters mentioned cannot be attempted here. It might, however, be of interest to review shortly how the water layers surrounding a certain area, in this case Bear Island, maintain temperatures below zero °C down to the bottom. The data are incomplete as not all months of the year, but only a greater or smaller part of it are included. Some information, however, might be gained.

1928. In August, September and early October no bottom water around Bear Island was noticed having temperatures below zero, neither was drifting ice observed during this interval.

1929. During the last days of May and first week of June the Bank in close proximity to Bear Island was covered with water of temperature below zero extending about 8 nautical miles to the northwest, ab. 16 n. m. to the southwest, ab. 8 n. m. to the south and ab. 29 n. m. to the east. On August 8th the layer of this cold water was still lying 6 n. m. out to the west. In other directions from the island observations are lacking. On September 23rd the water of temperature below zero had completely disappeared around Bear Island.

This year was an ice-year as regards the Bear Island Bank. On May 26th no ice was found, but in the course of a few days it came at full drive from the north and already on June 1st Bear Island was completely enveloped. The drifting ice stayed on the Bank partly covering this till the middle of July when it started to dwindle. On September 23rd no drifting ice was found off Bear Island.

1930. This year there was no drifting ice on April 24th or later on. In spring water of temperature below zero encircled Bear Island completely from the end of April till early June. This zone of cold water was in spring most narrow ab. 8 n. m. to the northwest, ab. 13 n. m. to the west and southwest, ab. 23 n. m. to the south and south-southeast and as usual somewhat wider to the southeast and east. In May this zone of water of temperature below zero had shrunk, and in latter part of June this zone had disappeared from the immediate surroundings of Bear Island, but a wide zone still was met with farther out to the east-southeast reaching ab. 25 n. m. outward. In July, August and September the area surrounding Bear Island was quite free from water of temperature below zero. However, still as late as September 22nd a small area was found ab. 15 n. m. to the southeast maintaining the cold water near the bottom.

1931. No drifting ice was observed off Bear Island on April 10th or later on. In spring a zone of water of temperature below zero surrounded Bear Island in April and early days of May extending ab. 14 n. m. to the north, ab. 11 n. m. to the northwest, at 17 n. m. to the west and southwest, ab. 14 n. m. to the south and south-southeast and ab. 25 n. m. to the east-southeast. At the end of May and early days of June this zone of cold water reached ab. 8 n. m. to the north, ab. 7 n. m. to the northwest and ab. 19 n. m. to the south-southeast. In other directions data of observation are lacking. On account of lack of data it is not known when the water of temperature below zero disapeared. On September 25th, however, none of this cold water was found to be present to the south and south-southeast.

1932—33. Upon the first visit to Bear Island on December 8th there was practically speaking no ice in process of formation. On December 11th some trash-ice was found forming off the west coast of the island. On December 22nd there was still no ice formation of importance. On February 9th Bear Island was surrounded by trash-ice ab. 18 n. m. to the southwest, ab. 20 n. m. to the southeast and considerably farther to the east and northeast.

In December the zone of water of temperature below zero extended ab. 10 n. m. to the west, ab. 14 n. m. to the southeast and east-southeast. On February 9th—12th this cold water stretched ab. 10 n. m. to the west and ab. 20 n. m. to the southeast.

According to these observations it seems as if the waters in the surroundings of Bear Island and on the shallow bank towards Hope Island due to the vertical circulation are being cooled from surface towards the bottom during November or when low air temperatures set in and before the ice begins to form on the surface. The zone of cold water is usually narrower to the west and northwest of the island than in other directions. This zone of cold water commences to shrink when the warmth of sun asserts itself in spring during May and June; and in years when the area is free from ice already in spring it usually seems to have practically disappeared in July– August. In years with drifting ice present in the course of summer the low temperatures of the water layers will be maintained, as the warmth of summer on account of the ice cover is being prevented from exercising efficient influence.

Similar conditions are encountered in the boundary waters farther to the north, but as drifting ice is here more frequently met with in the course of summer this prevents the warming of the water layers to a larger extent than what is the case in the more southern Bear Island waters.

If it is surmised that the cod usually do not frequent water masses of temperature below zero °C, then such changing conditions in the water masses must have considerable influence on the migrations of the cod in these localities. According to my experience cod in great numbers do not frequent grounds covered with water of temperature below zero, while good catches might be made in water of temperature approximating the zero point. An experiment especially intended to elucidate this fact more thoroughly was performed on May 3rd 1931 25 n. m. to the east-southeast of Bear Island in the bounds between temperate and cold water. One set of long-lines in water of temperature — 0.58 °C at the bottom yielded only: 1 Catfish *Anarrh. minor*, 4 Starry Rays *(Raja radiata)*. One set of lines 2.5 n. m. farther east

in water of temperature 1.24° C yielded: 2 Cod *(G. call.)*, 1 Halibut *(Hippoglossus vulgaris)*, 16 Catfish *(Anarrh. minor)*, 13 Starry Rays *(Raja radiata)*, 1 Greenland Shark. *(Somn. microcephalus)*.

In this connection it must be mentioned that at the same time at one station temperature readings were taken of the water layers at different hours of the day, a total of 9 readings a day. The first temperature reading was taken at 0.33 o'clock A. M. on May 3rd, the temperatures ranging from 0·8° C to 1·4° C from the bottom to surface. The succeeding 7 readings undertaken between 3.47 A. M. and 9.45 P. M. exhibited temperatures below zero all through the water layers, while the last reading taken at 0.35 A. M. on May 4th again showed temperatures above zero from bottom to the surface. The fact that the temperatures varied so greatly at the same place in the course of one day has to a certain extent reduced the value of said fishing experiments in the cold and in the temperate water, as the lines remained out for many hours and an exchange might have taken place also where the lines were set.

As a boundary area I further count the shallow waters off the estuary of the White Sea and those to the east past Kolguev where during intense cold spells in winter the whole volume of water usually is beeing cooled to temperatures below zero, this compelling the fish to seek westwards into the sea along the shores of Murmansk. In the latter region the water strata are temperate to the bottom all the year round within a zone extending north to about 72° Lat.; here the conditions commence to become altered as cold bottom layers with overlying warmer water will be encountered. Fish is here found pelagically in the temperate water strata. The extensive Barentz Sea stretching to the north, where drifting ice is formed in winter and which is approximately free from ice only in late summer of some years, has as a whole been investigated only to a small extent both as what regards the occurrence of fish as well as hydrography. But in its broad features it might be said that in the eastern portion of the Barentz Sea the water strata are pervasively colder and have a different stratification than what is the case in the western portion. Particularly to the northeast large parts of the area are found to be covered by cold water maintaining temperatures below zero from top to bottom all the year round. Under specific conditions only a thin top layer becomes heated by the air. The eastern portion of the Barentz Sea is, however, not as well known as the western one.

The warm Atlantic water flowing from the west between the Bear Island Bank and Norway has in summer temperatures which decrease towards the bottom. The Atlantic water is also carried north in the deep channel to the east of the Bear Island — Hope Island

bank, and while maintaining its type of stratification the temperatures are gradually decreasing towards the north. To the east of Hope Island the deep channel narrows fast and the depth decreases somewhat, but the channel continues in a northerly direction towards King Carls Land, where the depth again increases and the channel widens, the latter emerging between Franz Joseph Land and Victoria Island. The water strata in the deep to the east of Hope Island and further north are dispersed, having a temperate bottom layer and overlying strata of cold water. Our observations seem to indicate that the supply of temperate water on the bottom in the deep to the north of Hope Island is being conveyed from the north. A hydrographical station on 79° 38′ N, 39° 40′ E and situate somewhat to the south of the strait between Franz Joseph Land and Victoria Island showed on August 23rd 1929 a very thick and warm bottom layer having in its central part a temperature of almost 2,5° C., while at a section to the south of the latter in the latitude of King Carls Land bottom water was found having a temperature of only about 1° C. in its central part. Similar conditions, although appearing with less distinctness, were encountered also in 1923.

On August 26th 1923 a hydrographical station was worked to the east of Hope Island on the edge of the bank where it slopes towards the deep channel. The bottom water having a temperature of somewhat below 1° C. was here lying as a comparatively thin layer; overying this was a very thick, cold layer having a temperature of about — 1.5° C. in its central part. The upper 25 meters had been heated by the air, the surface attaining a temperature of 3° C. At this place capelin *(Mallotus villosus)* — which in small schools were chasing swarms of schizopods — were caught with seine. Using the newly caught capelin as bait experiments with long-lines were carried out at this station, these resulting in catches proving the presence of not small numbers of cod.

Fishing experiments with hand-lines have been carried out here and there also to the north in the Barentz Sea, although these did not result in catches. At the station previously referred to, situated to the south of the strait between Franz Joseph Land and Victoria Island and where the bottom layer was so very thick and warm, a vertically placed line with about a dozen of hooks attached („snik") was tried without yielding any fish.

In spite of these negative results I am of the opinion that cod at some time or another may appear in this region. At all events the hydrographical conditions do not seem completely to exclude the possibility that cod may migrate in temperate water from the west around the north coast of Svalbard or from the south from the Hope Island area.

Table I. *The Catch of Young Cod on and outside the*

Area	Position	Vessel	Year	Date	Station
A	76° 36′—37′ E 28° 16′ – 40′ ...	Tovik	1924	11/8	79
	75° 39′ E 26° 53′	Sotra	1930	12/7	143
B	76° 2′ E 17° 50′	Sotra	1930	11/6	86
	75° 29′ E 16° 20′—34′	„	1930	11/6	87
	75° 25′ E 17° 35′	„	1930	18/9	285
	75° 16′ E 17° 15′	„	1931	21/4	51 B
	75° 18′—20′ E 15° 57′	„	1931	16/6—17/6	133
C	Green Harbour	Blåfjell	1923	4/9	99
	—	„	1923	4/9	99
	—	„	1923	22/8	90
	—	Sotra	1930	8/9—9/9	250
	—	Veiding	1931	30/8	201
	—	„	1931	3/9	208
	—	„	1931	3/9	209 A
	—	„	1931	4/9	208 B
D	77° 47′—50′ E 10° 22′—55′ ...	Sotra	1930	2/9—5/9	245—246
E	79° 57′ E 11° 57′	Veiding	1931	8/9	211—212

Northern Boundary of Commercial Fisheries.

No. of Indv.	Size Group	Remarks
3	11·5—15 cm I	Shrimp trawl
2	14 – 16 cm I	Stomach contents of cod
2	13 cm I	Stomach contents of cod
1	I	— —
Many	I	— —
5	I	— —
Many	I	— —
49	3·5— 6 cm 0	Beach seine
9	10·5—17·7 cm I	—
29	0	—
A few	I	Shrimp trawl
44	12—20 cm I	—
5	II	—
Several	0	Beach seine (+ 1 coalfish young I)
38	12—32 cm I—II	Shrimp trawl
Many	I	Stomach contents of cod
56	27—63 cm II, III, IV, mostly III	Hand-line

Table II. *Norwegian Cod Marking*

Liberated			
Tagged by	Position	Date	Cm
Norwegian Directorate	63° 33′ E 7° 55′, Norway	21/8 1928	78
S/S "Kirkholmen" ...	74° 31′ E 20° 17′, Bear Island	22/8 1928	72
„ — ...	— —	—	71
„ — ...	74° 39′ E 18° 30′, —	5/9 1928	88
S/S "Sotra"	70° 51′ W 9° 2′, Jan Mayen.....	14/8 1930	90
„ —	— —	—	91
„ —	— —	—	113
„ —	— —	—	88
„ —	— —	—	85
S/S "Veiding"	65° 23′ W 37° 53′, South-east Greenland	3/8—4/8 1931	66
„ —	— —	—	89
„ —	— —	—	79
„ —	— —	—	77
„ —	— —	—	68
„ —	— —	—	71
„ —	— —	—	80
„ —	— —	—	87

Experiments 1928—30—31.

Recovered

Locality	Cm	Date	Months out.
90′ N—W of Bear Island	—	August 1928	ab. 5
5′ SSW of Henningsvær, Lofoten	73	19/2 1929	7
Off Borgevær, Lofoten	—	2/4 1931	31 1/2
15′ E of Kjølnes, Finnmark	92	19/2 1929	6 1/2
8′ SE of Westmanna Islands, South Iceland	95	11/3 1932	19
8′ NW of Westmanna Islands, South Iceland.	96	15/4 1931	8
Selvågbanki, South Iceland	117	26/4 1931	8 1/2
65° 23′ W 17° 42′, East Iceland	92	22/7 1932	23 3/4
Øyjafjord, North Iceland	87	4/4 1931	7 3/4
23′ N—E of North Cape, North Iceland	71	1/2 1932	6
30′ off Westmanna Islands, South Iceland	93	23/4 1932	8 3/4
Selvågbanki, South Iceland	82	7/4 1932	8
Hunafloi, North Iceland	82·5	24/5 1932	9 3/4
21′ NW of Akranes, South-west Iceland	69	12/3 1933	19 1/3
8′ W of Snefelnes, West Iceland	—	8/3 1933	19
Iceland	—	9/4 1933	20 1/6
64° 40′ W 24° 12′, West Iceland	95	2/5 1933	21

Table III. *Maturity of the Sexual Organs*

Period	Date	Position	Station	No. of Indv.	Maturity of	
					II	III
A	26/4—27/4	N 74° 41′ E 17° 52′	28	33	14	—
	29/4	N 74° 24′ E 17° 18′	33	39	14	—
	30/4	N 74° 14′ E 17° 56′	34	92	30	1
	23/4—30/4			164	58	1
B	4/5—5/5	N 74° 24′ E 17° 7′	38	89	16	—
	10/5	N 74° 22′ E 17° 3′	46	112	23	2
	4/5—10/5			201	39	2
C	29/5	N 77° 49′ E 10° 36′	66	4	1	—
D	11/6—12/6	N 75° 29′ E 16° 20′—34′	87	106	22	—
	12/6	N 75° 13′ E 16° 58′	88	128	35	—
	13/6	N 75° 2′ E 17° 0	89	104	41	—
	11/6—13/6			338	98	—
	19/6	N 74° 12′ E 22° 44′	98	88	21	—
	19/6	N 74° 13′ E 22° 8′	101	87	34	—
	20/6	N 74° 20′ E 23° 1′	103	89	33	—
	19/6—20/6			264	88	—
E	2/9—5/9	N 77° 50′ E 10° 22′	245	583	540	1
		N 77° 47′ E 10° 55′	241			
	21/9	N 74° 28′ E 18° 45′	293	89	79	10

of Cod above 70 cm. 1930.

Sexual Organs					%	%	%	%
IV	V	VI	VII	VIII	II	III—V	VI	VII—VIII
1	—	2	16	—				
1	—	—	21	3				
—	—	1	33	27				
2	—	3	70	30	35·4	1·8	1·8	61·0
—	—	—	35	38				
2	—	5	46	34				
2	—	5	81	72	19·4	2	2·5	76
—	—	2	1	—	25·0	0	50	25
—	—	—	60	24				
—	—	—	54	39				
—	—	—	32	31				
—	—	—	146	94	29·0	0	0	71·0
—	—	—	54	13				
—	—	—	41	12				
—	—	—	42	14				
—	—	—	137	39	33·3	0	0	66·6
—	—	—	7	35	92·8	0	0	7·2
—	—	—	—	—	88·8	11·2	0	0

Table IV. *Maturity of the Sexual Organs*

Period	Date	Position	Station	No. of Indv.	Maturity of	
					II	III
	10/4	N 74° 1′ E 20° 49′	12 B	20	20	—
	11/4—14/4	N 74° 28′ E 16° 41′	21	502	437	22
	15/4	N 74° 37′ E 16° 33′	22	186	156	5
	15/4—16/4	N 74° 23′ E 16° 44′	23	1190	1052	63
	17/4	N 74° 9′ E 16° 59′	24	63	55	4
	17/4	N 74° 1′ E 17° 6′	25	37	33	4
	11/4—17/4			1978	1733	98
	18/4	N 74° 40′ E 17° 28′	30	120	93	9
	18/4	N 74° 43′ E 17° 6′	31	70	64	5
	18/4	N 74° 43′ E 17° 32′	32	145	127	14
A	21/4	N 75° 10′ E 16° 12′	47 A	33	31	2
	22/4	N 74° 42′ E 17° 57′	58	28	25	3
	18/4—22/4			396	340	33
	23/4	N 73° 54′ E 19° 59′	62 B	105	92	9
	23/4—24/4	N 74° 3′ E 19° 54′	63	62	52	6
	24/4—25/4	N 74° 1′ E 20° 37′	64 B	306	276	23
	23/4—25/4			473	420	38
	27/4—30/4	Between Kjelvik and Kjøllefjord	65 A	481	188	10
	30/4	Off Gjesvær and Hjelmsøy	65 B	216	22	1
	1/5	N 71° 57′ E 24° 15′	66	18	3	—
	5/5	N 74° 23′ E 16° 51′	70	87	40	—
	5/5	N 74° 27′ E 16° 40′	71	23	8	1
	5/5—6/5	N 74° 32′ E 16° 37′	72	74	24	2
	6/5	N 74° 37′ E 16° 36′	73	14	4	1
	5/5—6/5			198	76	4
B	6/5—7/5	N 74° 3′ E 17° 52′	75	20	2	—
	7/5—8/5	N 73° 52′ E 17° 59′	76	48	11	—
	6/5—8/5			68	13	—
	12/5	N 74° 45′ E 17° 1′	80	23	7	—
	12/5—13/5	N 74° 45′ E 17° 26′	81	152	45	—
	13/5	N 75° 34′ E 16° 28′	82	26	14	—
	12/5—13/5			201	66	—

Fortsettes.

of Cod above 70 cm. 1931.

Sexual Organs					%	%	%	%
IV	V	VI	VII	VIII	II	III—V	VI	VII—VIII
—	—	—	—	—	100	—	—	—
10	4	29	—	—				
6	5	14	—	—				
25	29	18	3	—				
2	—	1	1	—				
—	—	—	—	—				
43	38	62	4	—	87·6	9·0	3·1	0·2
5	8	3	2	—				
—	—	1	—	—				
2	2	—	—	—				
—	—	—	—	—				
—	—	—	—	—				
7	10	4	2	—	86·0	12·5	1·0	0·5
2	1	—	1	—				
1	2	—	1	—				
6	1	—	—	—				
9	4	—	2	—	88·8	10·8	0	0·4
1	10	11	261	—	39·1	4·4	2·3	54·2
—	3	—	187	3	10·2	1·8	0	88·0
—	—	—	12	3	16·7	0	0	83·3
1	3	4	15	24				
1	—	2	4	7				
—	1	11	16	20				
1	1	5	1	1				
3	5	22	36	52	38·4	6·1	11·1	44·4
—	1	—	3	14				
—	—	—	10	27				
—	1	—	13	41	19·1	1·5	0	79·4
—	—	—	6	10				
—	—	—	17	90				
—	—	—	—	12				
—	—	—	23	112	32·8	0	0	67·2

Table IV (continued). *Maturity of the Sexual Organs*

Period	Date	Position	Station	No. of Indv.	Maturity of	
					II	III
	28/5	N 73° 55′ E 20° 6′	111	48	15	—
	29/5	N 73° 50′ E 18° 17′	112	42	16	—
	28/5—29/5			90	31	—
C	30/5	N 74° 29′ E 16° 42′	113	56	6	—
	30/5—31/5	N 74° 34′ E 17° 1′	114	51	7	—
	31/5—1/6	N 74° 21′ E 17° 17′	116 A	49	12	—
	1/6	N 74° 44′ E 17° 4′	117	39	11	1
	1/6—2/6	N 74° 27′ E 17° 32′	121	8	3	—
	30/5—2/6			203	39	1
	15/6	N 74° 58′ E 17° 5′	131	36	18	—
	16/6—17/6	N 75° 20′ E 16° 0′	133	83	40	—
D	22/6	N 75° 42′ E 17° 13′	135	43	13	—
	15/6—22/6			162	71	—
	20/6	N 77° 51′ E 10° 9′	134	76	15	—
	28/8	N 78° 0′ E 9° 54′	193	27	24	—
E	29/8	N 77° 47′ E 10° 45′	194	19	17	—
	29/8	N 77° 53′ E 12° 14′	199	63	59	—
	28/8—29/8			109	100	—

of Cod above 70 cm. 1931.

Sexual Organs					%	%	%	%
IV	V	VI	VII	VIII	II	III—V	VI	VII—VIII
1	—	—	14	18				
—	—	—	3	23				
1	—	—	17	41	34·4	1·1	0	64·5
2	2	6	11	29				
1	—	6	20	17				
—	1	—	12	24				
—	—	4	9	14				
—	—	1	1	3				
3	3	17	53	87	19·2	3·4	8·4	69
1	2	—	6	9				
—	—	—	6	37				
—	—	—	5	25				
1	2	—	17	71	43·8	1·9	0	54·3
—	—	—	3	58	19·7	0	0	80·3
—	—	—	1	2				
—	—	—	—	2				
—	—	—	—	4				
—	—	—	1	8	91·7	0	0	8·3

Table V. *Maturity of the Sexual Organs*

One Group 70—95 cm and one

Area	Date	Size Group Cm	No. of Indv.	Maturity of	
				II	III
1	15/12	73— 94	18	14	3
	—	97 - 107	5	2	2
	15/12 1932	73—107	23	16	5
2	12/12	76 — 95	39	17	18
	—	96—103	6	3	3
	12/12 1932	76—103	45	20	21
3	11/12—22/12	72— 95	45	6	29
	—	96—118	12	1	11
	11/12 - 22/12 1932	72—118	57	7	40
	13/2—15/2	70— 95	147	87	35
	—	96—124	34	11	13
	13/2—15/2 1933	70—124	181	98	48
4	2/1— 5/1	70— 95	93	48	22
	—	96—111	8	3	1
	2/1—5/1 1933	70—111	101	51	23
5	1/1—8/1	77— 95	33	8	9
	—	96—119	66	2	27
	1/1—8/1 1933	77—119	99	10	36
6	20/2—21/2	70— 95	120	106	8
	—	97 - 119	14	9	2
	20/2—21/2 1933	70—119	134	115	10
7	9/1—11/1	71— 95	60	23	15
	—	96—112	44	—	23
	9/1—11/1 1933	71—112	104	23	38
	25/1—3/2	70— 95	92	55	20
	—	96—140	22	2	6
	25/1—3/2 1933	70—140	114	57	26
8	24/1	70— 95	39	22	13
	—	96—108	7	—	5
	24/1 1933	70—108	46	22	18
9	20/1—21/1	70— 95	125	8	64
	—	96—108	24	—	17
	20/1—21/1 1933	70—108	149	8	81

of Cod in Winter 1932—1933.

Group above 95 cm are shown.

Sexual Organs					%	%	%	%
IV	V	VI	VII	VIII	II	III—V	VI	VII—VIII
1	—	—	—	—	78	22		
1	—	—	—	—	40	60		
2	—	—	—	—	69·6	30·4		
4	—	—	—	—	43·5	56·5		
—	—	—	—	—	50	50		
4	—	—	—	—	44·5	55·5		
10	—	—	—	—	13·3	86·7		
—	—	—	—	—	8·4	91·6		
10	—	—	—	—	12·3	87·7		
11	13	—	—	1	59·2	40·1	—	0·7
6	2	—	—	2	32·4	61.7	—	5·9
17	15	—	—	3	54·2	44·1	—	1·7
14	9	—	—	—	51·5	48·5		
4	—	—	—	—	37·5	62·5		
18	9	—	—	—	50·5	49·5		
14	1	—	—	1	24·2	72·8	—	3
33	2	—	1	1	3	94	—	3
47	3	—	1	2	10	87	—	3
4	2	—	—	—	88·5	11·5		
2	1	—	—	—	64·3	35·7		
6	3	—	—	—	85·8	14·2		
8	14	—	—	—	38·4	61·6		
8	13	—	—	—	—	100		
16	27	—	—	—	22	78		
11	5	1	—	—	59·8	39·1	1·1	
11	3	—	—	—	9	91	—	
22	8	1	—	—	50	49·1	0·9	
2	2	—	—	—	56·5	43·5		
1	1	—	—	—	—	100		
3	3	—	—	—	48	52		
24	29	—	—	—	6·4	93·6		
4	3	—	—	—	—	100		
28	32	—	—	—	5·4	94·6		